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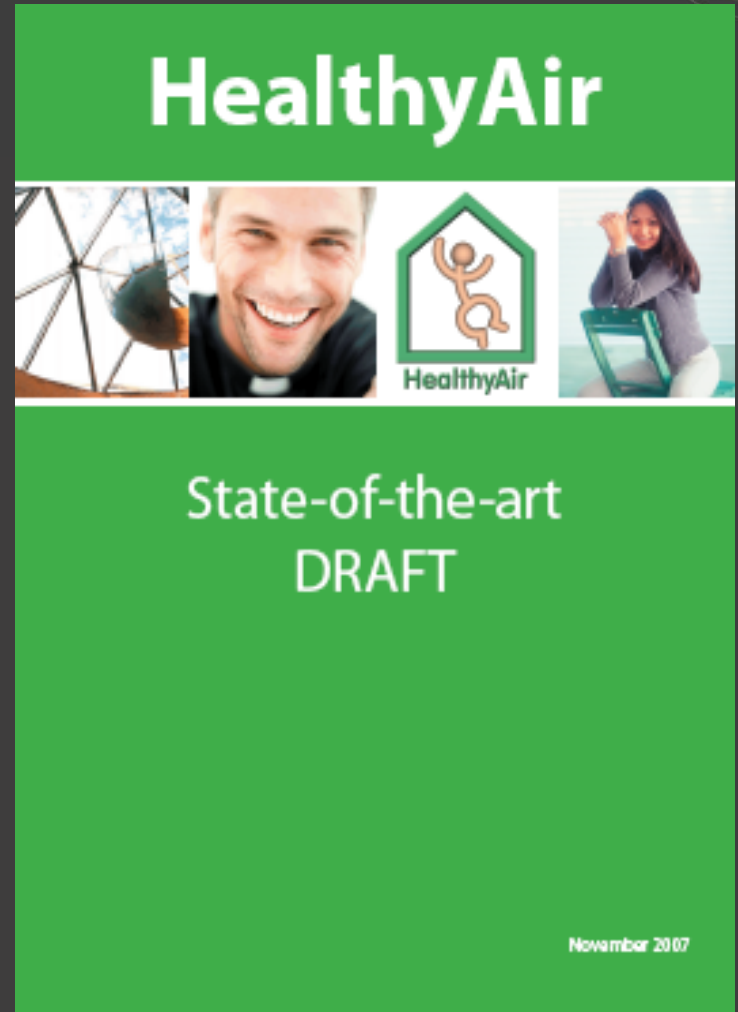
HealthyAir – The impact of building materials on
indoor air quality

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HealthyAir; State of the Art Review

- State of the art review on the effects of construction products on indoor air quality and assessment of these sources of pollution
- Contents of draft
 1. Introduction
 2. Sources
 3. Exposure and health effects
 4. Emission testing
 5. Strategies to reduce impact on IAQ

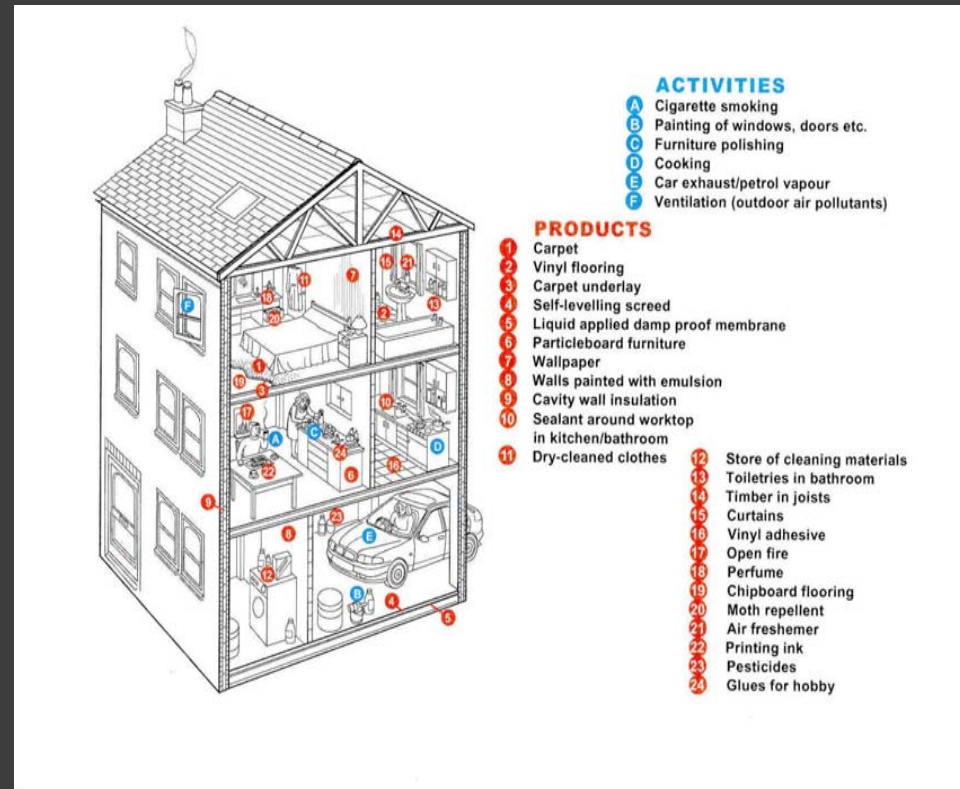


Indoor pollution

Indoor air pollution is the presence in buildings of toxic or other substances which may directly or indirectly be a cause of occupant ill health or discomfort.

Sources

- Outdoors
- Building materials and furnishings
- Occupant related activities and products
- Ventilation systems



Types and sources of indoor pollution

Source	Main pollutants
Outdoor air	SO ₂ , NO _x , CO, O ₃ , particulates, biological particulates, benzene
Combustion of fuel	CO, NO _x , VOCs, particulates
Tobacco smoke	CO, VOCs, particulates
People	(CO ₂), VOCs
Building materials	VOCs, formaldehyde, radon, fibres, other particulates (support mould growth)
Consumer products	VOCs, formaldehyde, pesticides
Furnishings	VOCs, formaldehyde
Office equipment, HVAC	VOCs, O ₃ , particulates
Washing and cleaning	Water, VOCs
animals	allergens
Contaminated land	Methane, VOCs

Example IAQ Guidelines and standards

- **WHO guidelines** for individual compounds relate to indoor and outdoor air e.g. toluene, styrene, formaldehyde.
- **EU INDEX** project IAQ guidelines
e.g. naphthalene, formaldehyde
- **Other National IAQ** guidelines / standards ;
e.g. Finland - 3 levels of indoor air quality; S1, S2 and S3.
Germany – for formaldehyde.
- **UK DH (COMEAP 2004)** recommended indoor air quality guidelines for homes
e.g. Benzene; annual mean $5 \mu\text{g m}^{-3}$
Formaldehyde; $100 \mu\text{g m}^{-3}$ (30 min)
Benzo[a]pyrene 0.25 ng m^{-3} provisional annual mean
- **Building Regulations Part F (Ventilation)**
Performance criteria for TVOC of $<300 \mu\text{g m}^{-3}$
- **COMEAP** IAQ standard for HCBD (0.6 ppb)

Occupational Exposure Limits



EU activities on IAQ

- European Environment and Health Strategy (SCALE)
- Action plan 2004-2010 (DG Sanco, ENV, RTD, JRC) adopted (EHAP); information/research/response.
- European Parliament report and resolution 2005; combat smoking, **research into impact on construction materials and health and introduce labelling**, request a green paper on domestic pollution
- Green paper on tobacco smoke policy options (2007)
- DGENV funding 'Ranking of indoor air health problems using health impact assessment (2007)
- Research in FP7 includes IAQ as topic



EU activity on IAQ (2)

- Scientific Committee on Health and Environmental Risks (SCHER) opinion on risk assessment on IAQ and risks of air fresheners.
- EU expert group set up in 2006 to advise on policies related to IAQ and reducing pollutant concentrations; draft work plan with 4 actions including ‘**working with manufacturers and constructors**’ to improve IAQ.
- Research by DGs; e.g. BUMA, ENVIE, HealthyAir, JRC particularly European Collaborative Action on IAQ
- **DG Enterprise and Industry** on requirements for emissions to indoor air under the **Construction Products Directive**



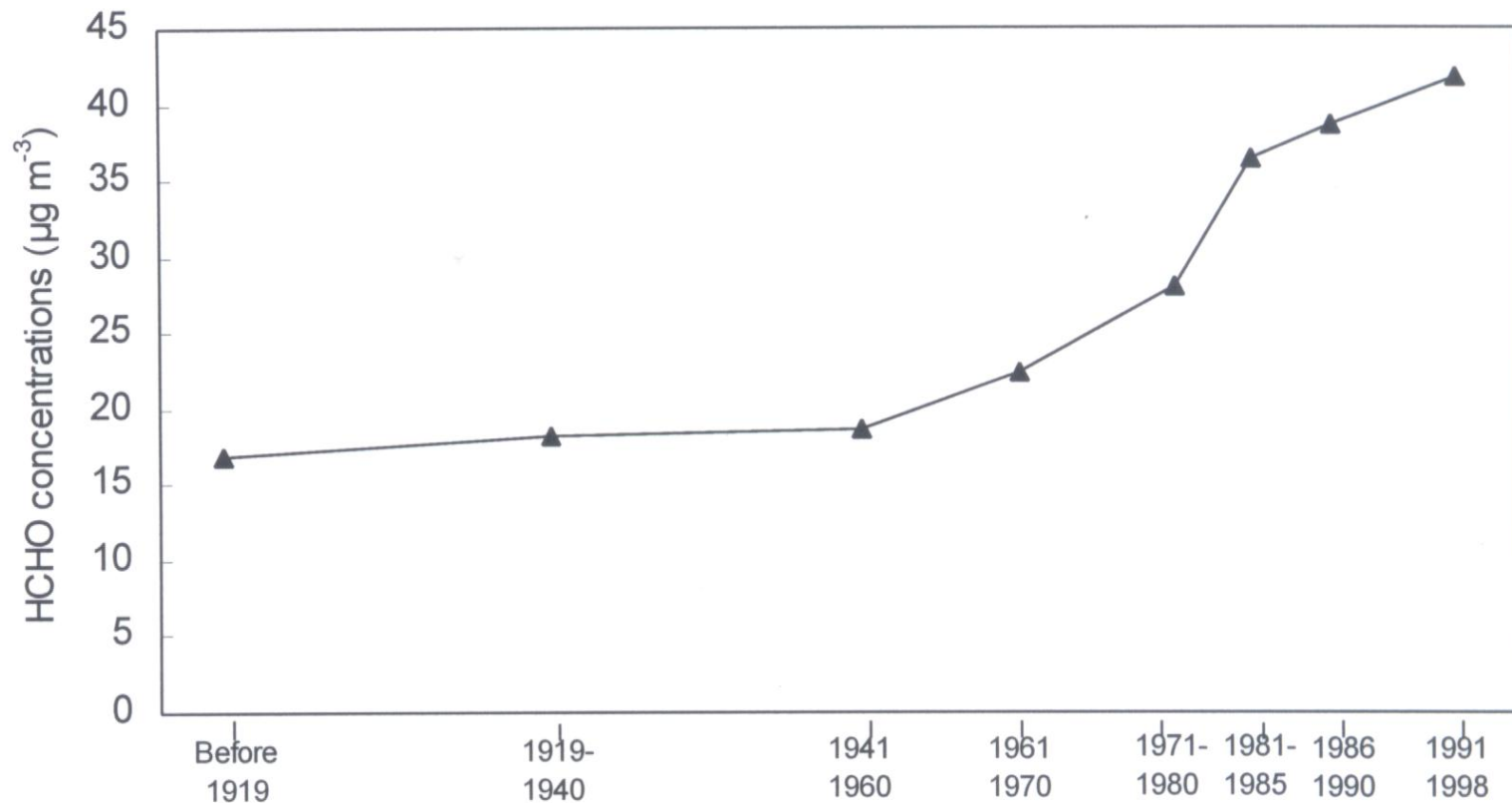
IAQ survey of England

- Homes selected as a sub-sample of the Survey of English Homes Oct 1997 - Feb 1999 undertaken by ONS.
- 876 participated successfully
- Diffusive sampling of VOCs, formaldehyde, NO₂ and CO
- Questionnaire about household activities
- BRE reports 433 and 446

Concentrations in homes in IAQ survey of England

compound	concentration $\mu\text{g m}^{-3}$		
	GM	10 th percentile	95 th percentile
NO ₂	11.9	4.4	38.1
CO	390	120	1680
Formaldehyde	22.2	9.8	61.2
TVOC	210	72	1010
Benzene	3	1	14.6
Toluene	15.1	4.4	74.9
limonene	6.2	1.3	51

Results - formaldehyde and age of house



Overview of main findings - TVOCs

- The following factors were found to have a causal effect on TVOC levels:
 - painting and decorating
 - season
 - house age
 - particleboard bedroom floor
- Other factors significantly associated because of age of house and particle board floors were; garage type, extract fan, occupant density and use of cleaning materials and toiletries.

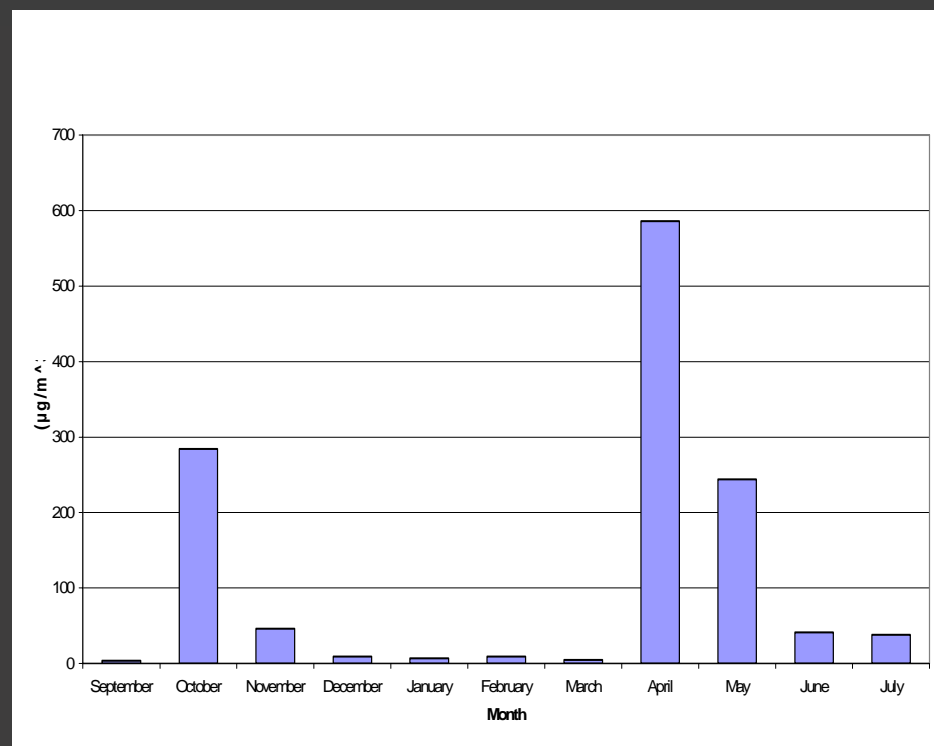
12 month study of school following refurbishment

- Primary school including nursery
- Built in 1970s and refurbished in 2003
- Undertook diffusive monitoring of VOCs and formaldehyde over 11 month period of school year
Monitored VOCs at 24 locations and aldehydes in offices
- Questionnaires applied to record any staff health symptoms

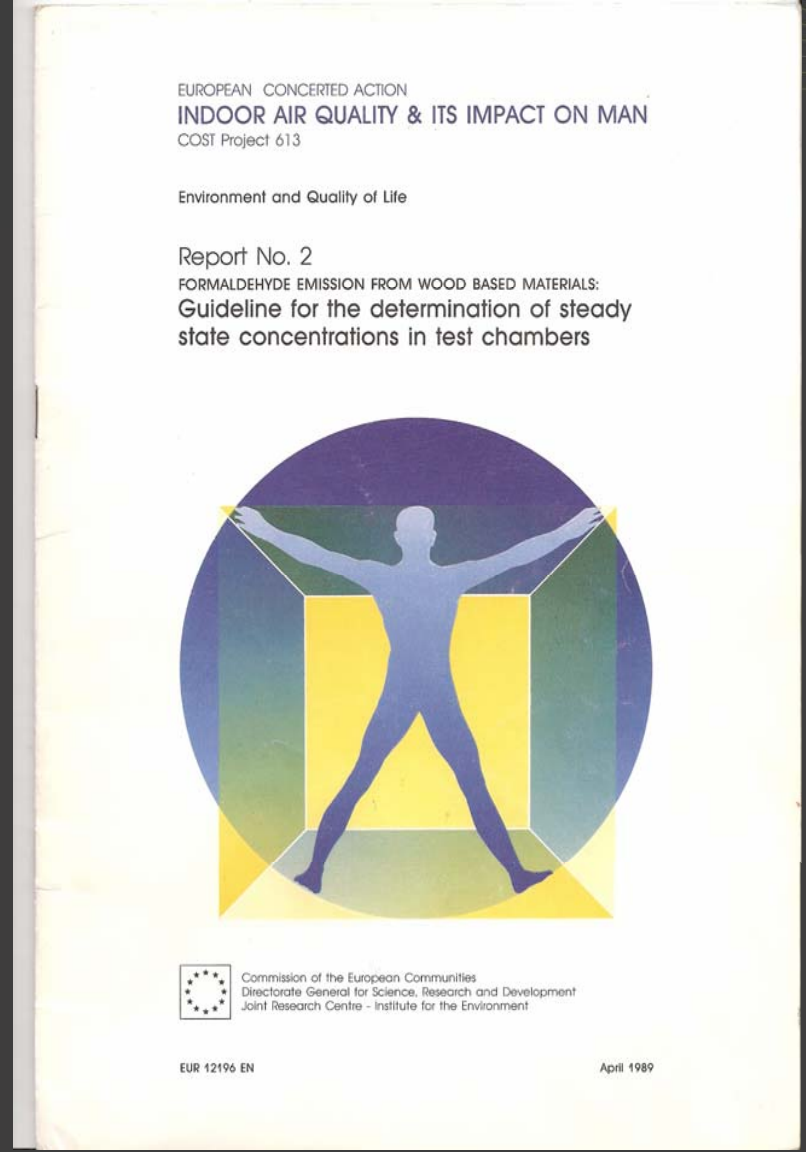


Toluene concentration in the nursery

- monthly mean concentrations exceeded the 7 day WHO guideline of $260 \mu\text{g m}^{-3}$ for toluene during October and April
- Monthly mean very close to guideline value in May
- Peak concentrations were concurrent with building and decorating activities in the nursery or nearby area
- While some peaks occurred during school holidays the guideline was exceeded during periods the school was in use



Testing formaldehyde emission from wood based products - ECA 1989 (report no. 2)



Emission types

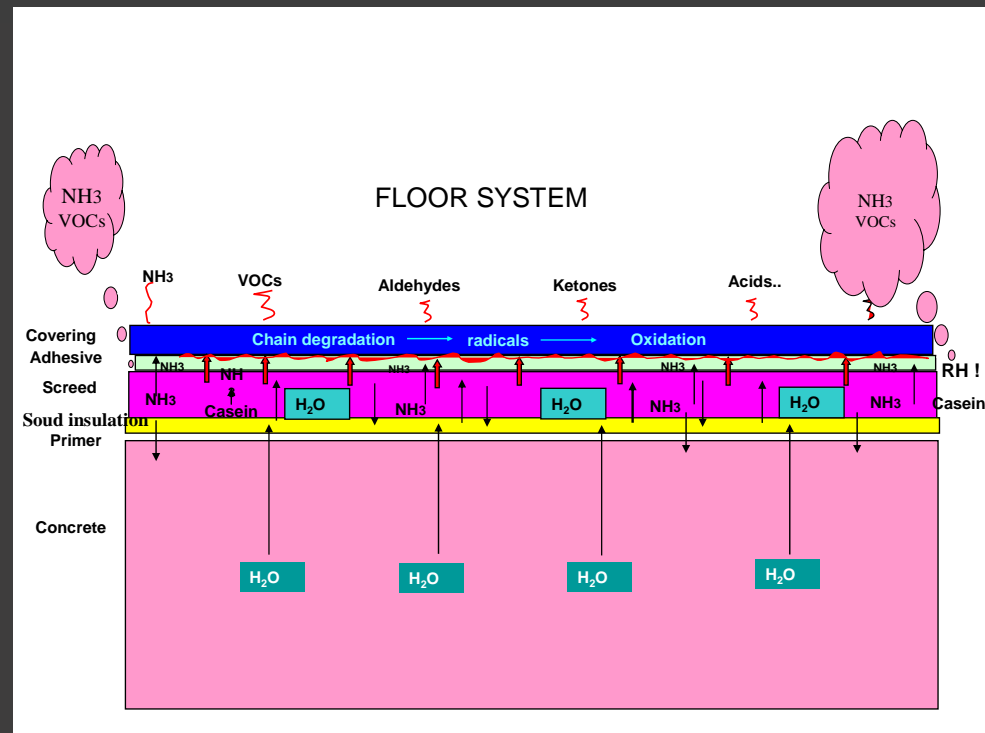
- **Primary;**
emissions of particles / gases that originate from the product itself e.g. organics from floor and wall covering, pesticides, formaldehyde from wood based products, particles (fibres) from insulation
- **Secondary;**
 - re-emission of pollutants adsorbed to surfaces and desorbed at a later time and re-suspension (can include HVAC)
 - indoor chemistry that transforms indoor pollutants emitted from primary sources, or from outdoors, to different indoor pollutants

Factors determining emission

- Mass transfer processes; evaporation, sorption, diffusion, convection
- Environmental variables; temperature, humidity, air change rate, air velocity and turbulence
- Product characteristics and composition; types of chemical, chemical properties, product complexity, manufacturing process.

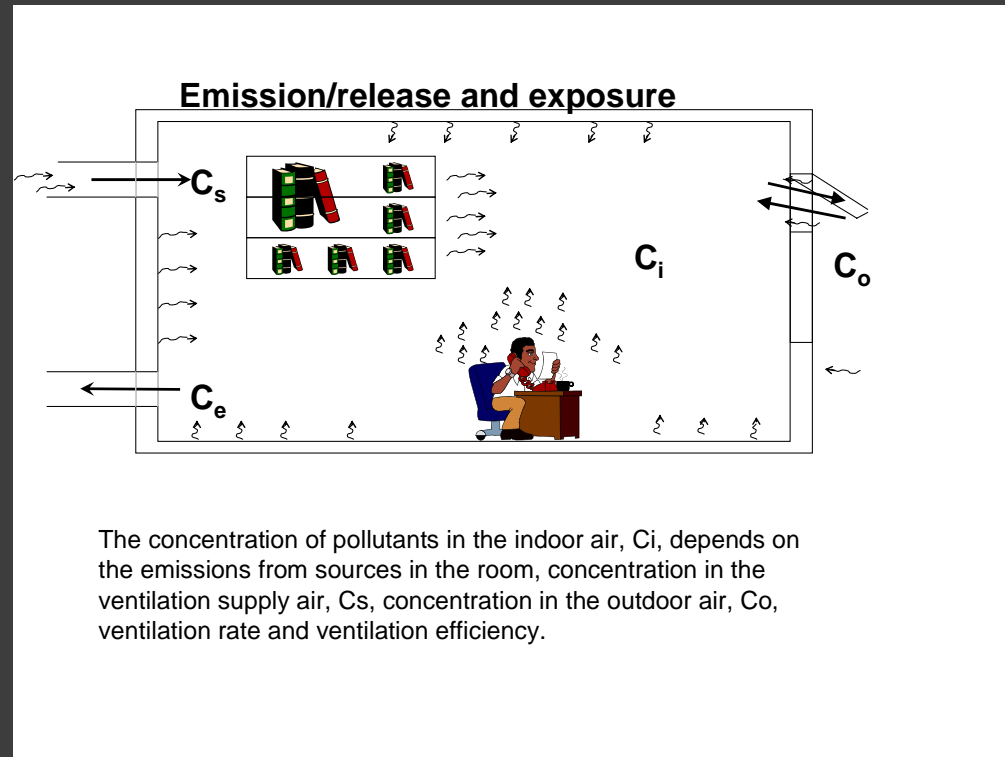
Indoor chemistry

- Reactions occur in air and on surfaces
- Most studied are gas phase reactions involving O_3 and free radicals
- To be influential rate of reaction must be sufficient with respect to indoor ach^{-1}
- e.g. terpenes + $O_3 \rightarrow$ gas phase (aldehydes, carboxylic acids, peroxides) and particle phase (fine and ultrafine) products



Exposure to indoor pollutants

- Indoor concentration depends upon rate of emission ($\mu\text{g/s}$) and rate of removal of pollutant
- Emission may be continuous (constant or variable) or intermittent
- May be several sources of one pollutant with different characteristics
- Dynamic relationship between emission and removal by ventilation and sinks



Health effects

- Variety of health outcomes related to pollutant exposure;
 - Acute toxicity (e.g. respiratory irritation)
 - Chronic toxicity (e.g. cancer)
 - Reproductive effects
- Odour also is an important aspect of impact of product on IAQ
- Possible interaction e.g. O_3 + PM potentiate



Chemicals – some health issues

- Irritant and toxic properties of individual compounds
- Chronic effects, primarily cancer
- Guideline concentration (WHO, INDEX) to protect populations
- Effects of mixtures e.g. chemosensory irritation of eyes and nasal passages
- VOCs in relation to asthma controversial
- Plasticisers; concern raised about link to allergic diseases
- Relationships between stress, irritation and perceived effects of VOCs
- SVOCs in dust ingested



Health - particles

- Linked to acute and chronic effects including asthma and cardiac disease
- May potentiate effects of allergens
- Fine particles decrease FEV1 in asthmatic children
- Most studies are of links between outdoor exposure and hospital admissions & mortality
- Significance of different characteristics of indoor and outdoor particles not known

Biohazards - health

- Animal allergen and asthma e.g. mite, cat, dog
- Damp indoor environments associated with respiratory tract infection
- Possible effects of mold spores, mycotoxins and glucans (no consensus)
- Infectious agents



Control of emission from building products

- **Product material assessment**

Review information, benchtop tests, source emission model, dynamic chamber tests

- **Exposure assessment**

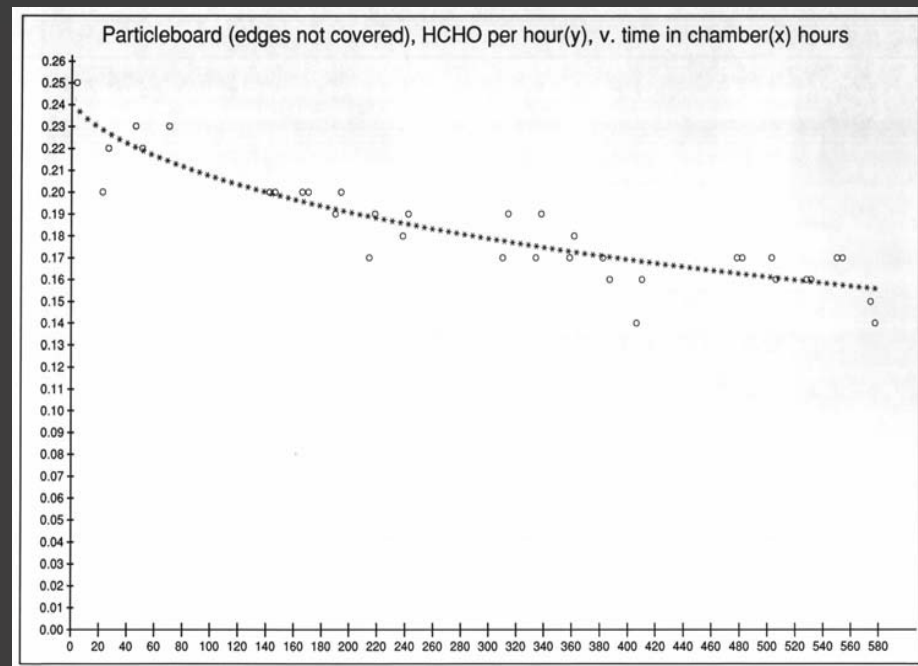
Relate emission to concentration and activity pattern (exposure scenarios)

- **Health risk assessment**

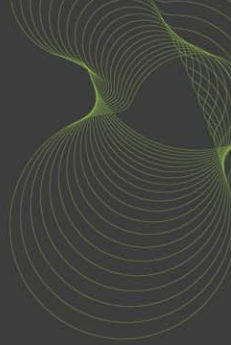
Identification and quantification of health hazard associated with exposure

Chamber testing of formaldehyde release from particleboard EN717-1

- Conditions 1 ach, 23°C, 45%RH,
- loading ratio of 1 m² m⁻³
- Determine steady state based on change in formaldehyde concentration over 4 consecutive days
- Minimum test period of 10 days and maximum of 28 days
- Development supported by EU funded round robin study completed in 1993
- **Note no measurement of other VOCs**



Development of CEN standards on control of formaldehyde release from wood based panels



- CEN TC 112 developed standard BS EN13986:2004
- Initial Type Test by chamber method to determine steady state formaldehyde concentration (EN 717-1)
- Classification of product (E1, E2) based on formaldehyde concentration in chamber (E1 = $<0.124 \text{ mg m}^{-3}$ in air)
- Factory Production Control using perforator test (EN120) for unfaced particleboard, OSB and MDF and gas analysis method (EN 717-2) for other products such as plywood and coated particleboard
- Need to determine content of PCP if present in raw materials
- **Vertical standard**; applies to one product group and compound



Construction Products Directive

- European Council Directive 89/106/EEC
- Essential Requirement No.3; Hygiene, Health and the Environment
- a healthy indoor environment can be achieved by the controlling of sources and by eliminating or limiting the release of pollutants into the air



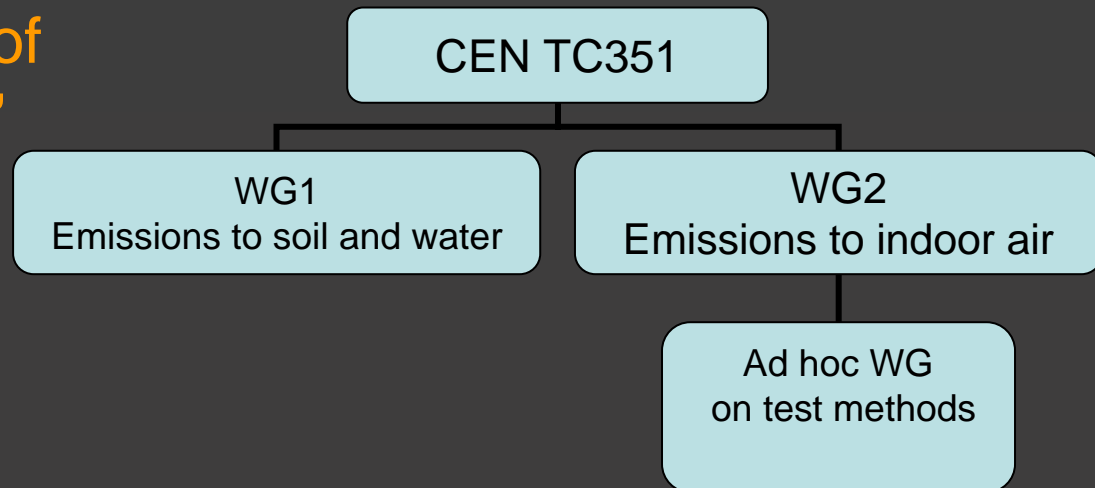
Mandate M/366 features

- Product emissions under normal conditions of use
- Test methods have horizontal character, wherever possible
- Consider emission not content wherever possible
- Methods validated
- New CEN standard committee TC 351 formed in April 2006



New Technical Committee (TC 351)

- Title; 'Construction products: assessment of dangerous substances'
- Scope; 'Development of horizontal standard assessment methods for harmonised approaches relating to dangerous substances under the CPD; Emission to indoor air, soil, surface water and ground water.'



WG 2 activities

- Identified relevant existing CEN and ISO standards
- Liaison with Product TCs about existing testing of dangerous substances
- Agreed to proceed to define standards for horizontal testing of emissions of formaldehyde and VOCs (pending final list from EGDS)
- Set up ad hoc group to draft 'umbrella standard' for testing emissions from building products
- Plan to undertake validation exercise for test methods

EN ISO standards on VOC emissions from building products – horizontal

- **EN ISO 16000-9;**
Emission test chamber
- **EN ISO 16000-10;**
Emission test cell method
- **EN ISO 16000-11;**
Sampling, storage of samples and preparation of test specimens
- **ISO 16000-6;**
Measurement of VOCs in indoor and chamber air



EN ISO 16000-9, 10 and 11

- 23°C, 50%RH
- Requirements for control of conditions and recovery of released chemical
- Minimum requirement for sampling of chamber / cell after 3 and 28 days
- informative annex defining model room (17.4 m³, 0.5 ach⁻¹) and area specific air flow rate for product types



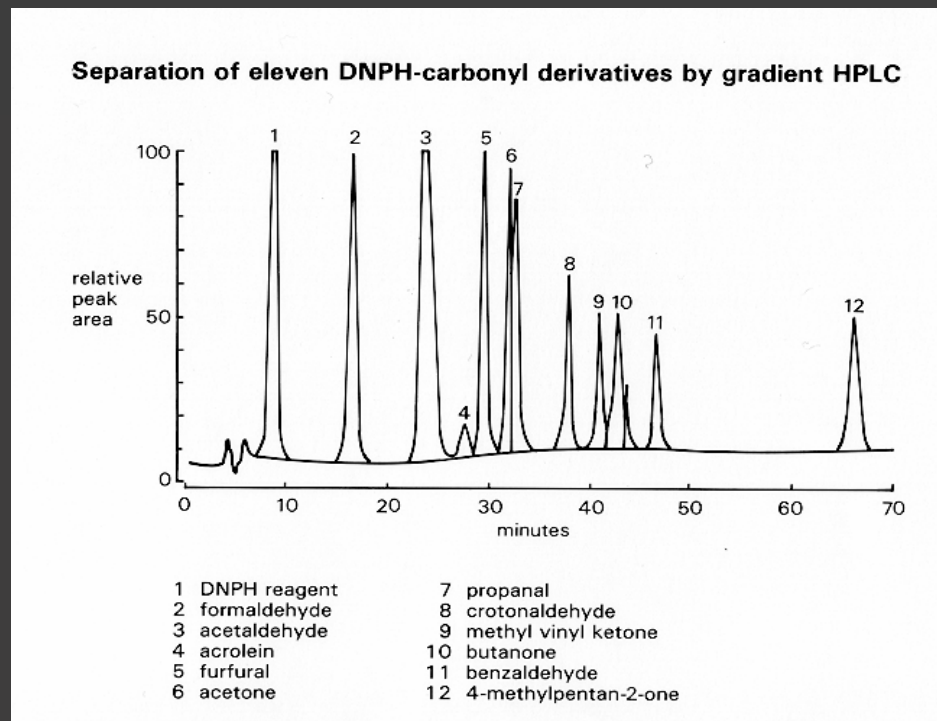
ISO 16000-6: 2004

Measurement of VOC in indoor air and chamber air by pumped sampling using Tenax TA adsorbent tube and analysis by thermal desorption / gas chromatography with FID/MS detection



Other relevant EN and ISO standards on chamber air analysis

- ISO 16000-3 Measurement of aldehydes in indoor air (pumped)
- EN ISO 16017-1 Guidance on methods of VOC measurement in air (pumped); details available absorbents appropriate for VVOC and SVOC as well as VOC range defined by ISO 16000-6



Examples of European labelling schemes for materials based on VOC emission;

- Finnish classification of finishing materials
 - The indoor climate label (Denmark and Norway)
 - Swedish floor covering standard
 - Nordic swan ecolabelling scheme
 - AgBB scheme for building materials in Germany (national regulation for flooring)
 - EMICODE for flooring adhesives (Germany based)
 - GUT for carpets (Germany based)
 - German Blue Angel e.g. furniture
- (ECA report no. 24 reviews the schemes in Europe)

Sensory testing

- Detection threshold
- Intensity; reference odours or rating without reference
- Quality; a value judgement, acceptability
- New work item in ISO TC146 SC6



US assessment / certification programmes

- **Indoor air emission labels / certification**

Greenguard (low emitting product certification)

California 01350 and CHPS (schools)

Carpet and Rug Institute; Green Label

Resilient Floor Covering Institute; FloorScore

Scientific Certification Systems; Indoor advantage

Hardwood Plywood and Veneer Association

- **Green product programmes (include IAQ criteria)**

Green Seal, US Green Building Council, US EPA energy star indoor package

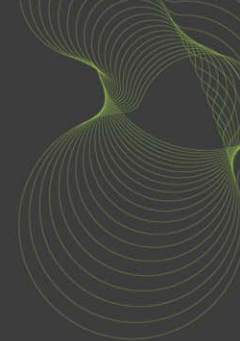


Zero carbon housing

- ‘within 10 years every new home will be zero carbon’ (HM Treasury, Nov 2006)
- Expect implications for materials used, types of heating appliance, and ventilation



Informing and involving key stakeholders



The groups

- Producers of products used in buildings
- Specifiers of products used in buildings
- People who use building

Communication

- Leaflets and booklets
- Internet pages
- Guidance documents
- Tools e.g. databases of products
- Labels that are recognised
- Research papers
- Media (TV, radio, papers, magazines)

Conclusions

- EU has a number of current activities to inform policy development on improving IAQ
- Control of sources, and building materials in particular, has been identified as a key issue for action
- The CPD provides a regulatory framework for control of emissions from construction products
- Chamber emission method(s) are expected to be the horizontal reference for type testing of products
- Existing voluntary labeling schemes encourage use of low emitting products but are limited in coverage (area and products) and have different end points
- Awareness of all stakeholders about IAQ needs to be raised as part of an effective strategy to reduce the impact of construction products on IAQ



